Research Product 88-39

Procedures and Guidelines for Thermal Imaging

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Fort Benning Field Unit
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U.S. Army Research Institute for the Behavioral and Social Sciences

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The thermal training package comprises a handbook and a slide presentation with accompanying script. The handbook contains a description of how the thermal sight works; a review of the thermal controls; and step-by-step procedures for obtaining an initial thermal image, for pre-marking control settings to facilitate obtaining a thermal image, and for scanning a sector; there are also guidelines to help gunners classify detections and estimate range. The scripted slide presentation shows BFV personnel the capabilities of the thermal sight and teaches them how to interpret a thermal image and recognize thermal cues.

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FOREWORD

The Army Research Institute for the Behavioral and Social Sciences (ARI) has contributed to a program to define emerging problems and address critical issues affecting the Bradley Fighting Vehicle (BFV). Consistent with that program, this handbook and accompanying scripted slide presentation describe basic procedures for using the thermal sight of the BFV and guidance in interpreting thermal images. The instructional package will be an effective teaching tool in the classroom and for informal training or self-instruction.

ARI's Fort Benning Field Unit, a division of the Training Research Laboratory, monitored this research. ARI's mission is to conduct research of training and training technology using infantry combat systems and problems as mediums. The research task that supports this mission is 3.4.2., "Advanced Methods and Systems for Fighting Vehicle Training," organized under the "Train the Force" program area. Sponsorship for this research is provided by a Memorandum of Understanding (effective 31 May 1983) between the U.S. Army Infantry School (USAIS), Training and Doctrine Command, Training Technology Agency, and ARI, which established how joint efforts to improve BFV tactical doctrine, unit, and gunnery training would proceed.

The results of this research were formally briefed to the Commander, 1st Battalion, 29th Infantry Regiment and the Master Gunner and Commander/Gunner Course instructors. Selected personnel from the U.S. Army Infantry School Directorate of Training and Doctrine and Combat Developments have requested the material for potential use in the Army-wide effort to improve thermal image training.

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ABOUT THIS HANDBOOK

This student handbook contains basic procedures and guidelines for using the thermal sight of the Bradley Fighting Vehicle and tells the gunner how to obtain a good thermal image, how to scan effectively, and what to do when a target is detected. It also provides guidelines to help him estimate the range to the target.

This handbook, which is part of a thermal training package that includes a slide presentation, will be most useful to gunners who have seen the presentation; however, it is designed so that it may be used alone. It may be used as a classroom teaching document, and 11 vu-graphs are provided. But the handbook is primarily intended to be used for informal training and self-instruction.

PROCEDURES AND GUIDELINES FOR THERMAL IMAGING

CONTENTS

LIST OF DIAGRAMS

PROCEDURES AND GUIDELINES FOR THERMAL IMAGING

I. INTRODUCTION

The Thermal Sight is part of the Integrated Sight Unit (ISU). It is for use in daylight, at night and in conditions of limited visibility.

In DAYLIGHT, it can be used to check suspected positions for heat sources. It will allow the gunner to 'see' through camouflage netting and smoke, and will let him locate enemy units that are screened by light vegetation or hidden in deep shadow. In daylight, it does NOT replace the daylight sight, but used together with the daylight sight it gives the gunner a greater chance of detecting the enemy than he would have using the daylight sight alone.

At NIGHT and during periods of limited visibility (LIMVIS) it is the primary method available on the Bradley of detecting and engaging the enemy.

HOW THE THERMAL SIGHT WORKS

A thermal sight works by sensing the differences in the amount of heat radiated by buildings, trees, vehicles, animals and people. The thermal imaging unit turns this heat into a visual display that the gunner sees through the sight. The greater the difference in the heat radiated by two objects, the more clearly they can be seen as separate. For this reason a tank travelling across snow stands out very clearly, but a tank that has been parked among trees for many hours will be harder to detect. The thermal sight will detect very minor differences in temperature.

The four main sources of heat that make detection possible are:

1) Solar heat. Trees, buildings, vehicles, grass and soil absorb heat from the sun and radiate it back into the air. However, the rate at which they radiate heat back into the air varies. The different radiation rates make it possible to see the different objects.

2) Fuel combustion. Because engines generate heat, the engine areas and exhaust show up more clearly than do other parts of a vehicle. Also tents and buildings heated by stoves may give good thermal signatures.

3) Friction. Heat is generated by moving parts rubbing together, and by friction between tracks, tires and the road. Therefore, drive sprockets, rollers, wheels, and shock absorbers will show clearly in the sights when a vehicle is moving, and will continue to radiate heat for some time after the vehicle has stopped.

4) Body Heat. Animals and people give off heat, which is detectable by the thermal sight.

LIMITATIONS OF THE SIGHT.

On a clear, cold, dry night, a gunner using a well-maintained thermal sight can detect targets, even personnel, at ranges in excess of 4000 meters. Three factors will degrade his performance. These are the weather, the state of maintenance of the sight, and the ability of the gunner to use the sight effectively.

THE WEATHER. Moisture in the atmosphere absorbs heat. The more moisture there is in the atmosphere, the greater the amount of radiated heat that is absorbed, and therefore less reaches the thermal sight. This means that the thermal image will not be as clear in fog, rain or snow as it is in dry weather. It also means that the range at which targets can be detected is less.

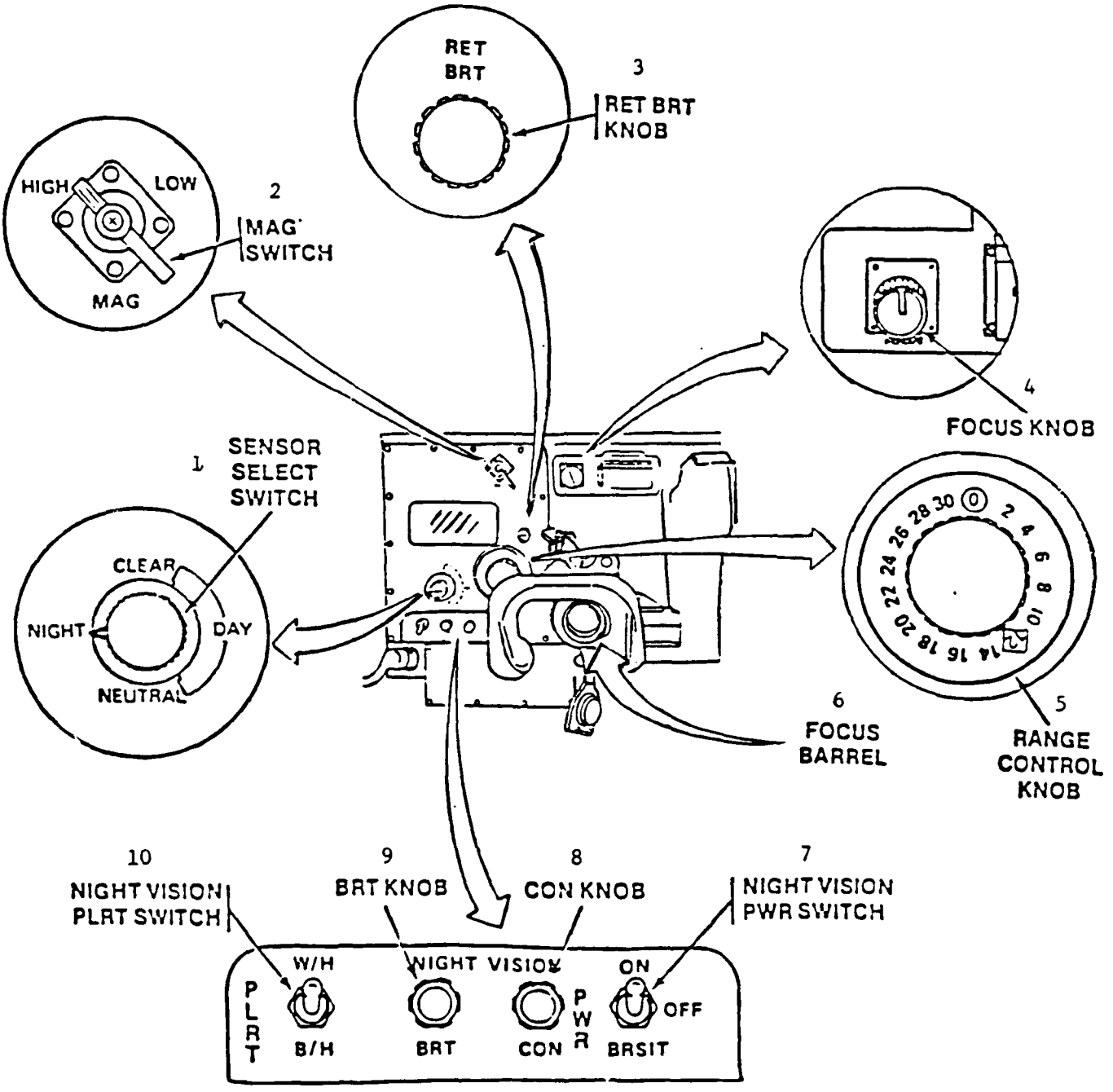
MAINTENANCE. A sight needs regular maintenance. As this becomes due, or if it is neglected, the ability of the sight to sense differences in temperature will be reduced, so that even in perfect conditions detections may become difficult at 2000 meters. The gunner may not do maintenance, but he can help by making sure that the eyepiece and unity window on the inside, and the ISU day and night windows on the outside of the vehicle, are kept clean.

THE GUNNER. The thermal sight is an effective tool when used correctly. However, obtaining a clear thermal image, and understanding what the sight shows when the image is obtained, requires knowledge and practice.

II. REVIEW OF THE AL SIGHT CONTROLS.

1. SENSOR SELECT SWITCH.	CLEAR setting allows target viewing under normal daylight conditions. NEUTRAL setting also allows target viewing under normal daylight conditions, but it filters out bright sunlight. NIGHT setting allows target viewing through the thermal imaging system.
2. MAG [MAGNIFICATION] SWITCH.	Selects HIGH and LOW magnification of scene for both day and night vision. LOW setting is 4X magnification. HIGH setting is 12X magnification.
3. RET [RETICLE] BRT [BRIGHTNESS] KNOB.	Adjusts the brightness of the reticles for both the 25-mm. gun and for the TOW, in both DAY and NIGHT (thermal) modes.
4. FOCUS KNOB.	Adjusts the focus of the thermal sight so that objects at different ranges become clear.
5. RANGE CONTROL KNOB.	Sets range from 0 to 3000 meters.
6. FOCUS BARREL.	Adjusts lens so that a clear image is obtained through the daylight sight, and sharpens image of reticle in gunner's eyepiece. When the daylight image and/or reticle is sharp and clear, the sight is adjusted for the gunner's eye.
7. NIGHT VISION PWR [POWER] SWITCH.	ON position turns on night sight. BRSIT position turns on night sight boresight lamp and thermal resistor for buddy boresight procedure.
8. CON [CONTRAST] KNOB.	Adjusts the contrast of the thermal image in the night (thermal) sight; that is to say it increases or reduces the difference between the lightest and darkest parts of the thermal display.
9. BRT [BRIGHTNESS] KNOB.	Adjusts the overall brightness so that all parts of the thermal display become either brighter or darker.
10. NIGHT VISION PLRT [POLARITY] SWITCH.	W/H (white hot) makes heat sources appear lighter (light red to almost white). B/H (black hot) makes heat sources appear darker (dark red to black).

Diagram 1. THERMAL SIGHT CONTROLS



III. PROCEDURE FOR OBTAINING AN INITIAL CLEAR THERMAL IMAGE.

Follow steps 1 to 20 to obtain a clear thermal image. Once a clear image has been obtained, only small adjustments of Focus, Brightness, and Contrast will be needed for targets at other ranges or when making changes in magnification.

1. Release TURRET TRAVEL LOCK.

2. Switch TURRET POWER on.

3. Switch NIGHT SIGHT POWER on.

4. Open BALLISTIC SIGHT COVERS.

5. Turn SENSOR SELECT to CLEAR.

Do steps 4-13 while sight cools down. Note: Night Sights vary in the time they take to cool. Usually they take about 3 minutes, and they should never take more than 10.

6. Switch HIGH/LOW MAG to LOW.

7. Set SIGHT on object at least 100 meters away.

Examples: A vehicle, tree, sign post, edge of building.

8. Adjust FOCUS BARREL until object is sharp and clear. (diopter focus)

This will adjust lens for the individual's eye in daylight.

Note: If FOCUS BARREL must be set in limited visibility conditions (night, fog, smoke), turn on reticle to low/medium brightness and adjust FOCUS BARREL until reticle is sharp and clear.

9. Turn SENSOR SELECT to NIGHT.

10. Switch polarity (PLRT) to white hot (W/H).

STEPS 11-13 DELIBERATELY TAKE CONTROLS OUT OF ADJUSTMENT.

11. Rotate thermal sight FOCUS KNOB to right until it stops.

May take 1-12 rotations.

12. Rotate contrast knob (CON) to right until it stops.

13. Rotate brightness knob (BRT) to right until it stops.

Note: Do NOT proceed unless sight has cooled. If sight has not cooled, then a good thermal image cannot be obtained.

14. Look through SIGHT. A bright red rectangle should be seen.

If no red rectangle, then call maintenance.

TO OBTAIN A CLEAR IMAGE.

15. Rotate CON knob left a quarter turn.

16. Rotate BRT knob left until some darkness is seen in the thermal field.

17. Slowly rotate FOCUS KNOB to left until sharpest possible image is obtained.

May take 2-10 rotations to obtain focus, usually 4-6. Focus will occur during a small part of one rotation.

18. Switch HIGH/LOW MAG to HIGH.

19. Readjust FOCUS, BRT and CON to obtain clearest possible image.

Sight is focused.

20. Adjust FOCUS BARREL (diopter focus) as necessary.

The sights are now correctly set for the object on which the sight is focused, and for the range of that object. This setting will provide a thermal image for objects at other ranges, in both high and low magnification.

REMEMBER: WITH EACH CHANGE OF RANGE OR MAGNIFICATION THE THERMAL FOCUS WILL NEED SHARPENING

IV. PROCEDURE FOR MARKING CONTROLS FOR RAPID FOCUS.

Use this procedure to mark the Brightness (BRT), Contrast (CON), and Focus controls so that a thermal image can be obtained quickly and easily on future occasions.

DO NOT USE THIS PROCEDURE UNLESS AUTHORIZED BY YOUR PLATOON LEADER.

Use white tape, correction fluid or similar removable material for marking. Chalk may be used to try out the procedure.

1. Obtain a good, clear, thermal image (Use procedure in section III).

2. Without moving the controls, mark the BRT setting with two dots. Put the first dot on the face of the knob and the second dot on the panel so that the dots are in line. If the knob has a white line on its side, line up the dots with it. See diagram 2.

3. Mark CON setting in same way.

4. COUNTING THE NUMBER OF FULL (360-degree) TURNS, rotate the FOCUS knob to the right until it stops. Example: the knob may rotate 5 full turns and one part turn.

5. Rotate the FOCUS back to left exactly the same number of rotations.

6. Check that the image is clear and make fine adjustments as needed to get the image as clear as possible.

7. WITHOUT DISTURBING THE SETTING, write the number of full rotations on the knob face, and mark the focus setting with two dots. Put the first dot on knob face and the second on the panel so that the dots are in line. If the knob has a white line on its side, line the dots up with it. See diagram 2.

The CONTRAST, BRIGHTNESS and FOCUS control settings are now marked for rapid focus. On future occasions, follow steps A and B below.

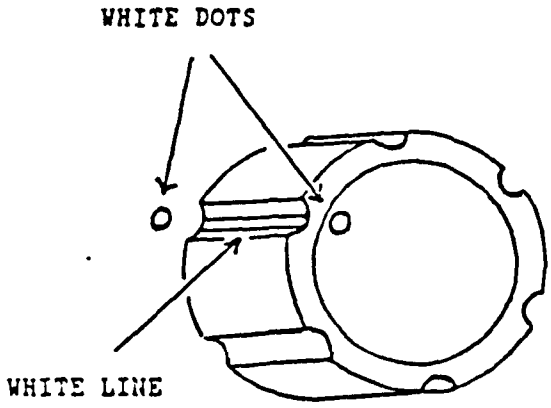
A. CONTRAST and BRIGHTNESS: line up the dots on the knob face with the dots on the panel.

B. FOCUS: Rotate the FOCUS knob to the right until it stops. Rotate the FOCUS knob back to the left the number of full rotations shown on the knob face. Continue rotating the FOCUS knob to the left until the dots line up.

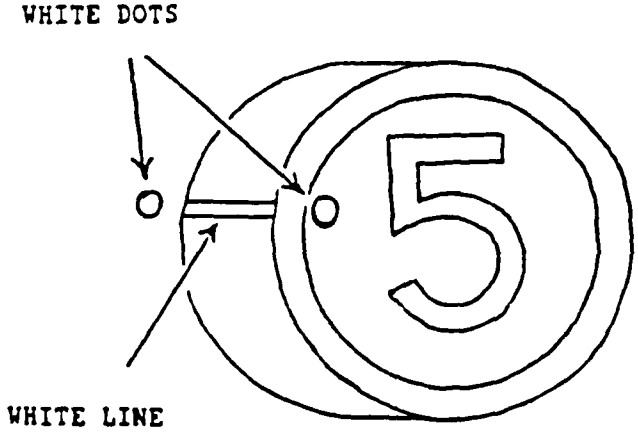
This permits the Brightness, Contrast and Focus Controls to be set while the sight is cooling. When the sight has cooled, the image will need only minor adjustment.

NOTE: These control knob markings will have to be checked, AND MAY HAVE TO BE CHANGED, when ISU is replaced or major repairs have been made.

Diagram 2. METHOD OF MARKING THE CONTROLS



MARKINGS FOR BRIGHTNESS AND CONTRAST CONTROLS



MARKINGS FOR FOCUS KNOB

V. CHECKLIST FOR OBTAINING INITIAL THERMAL IMAGE USING MARKED CONTROLS.

Only use checklist if Focus, Contrast, and Brightness controls have been marked as described on page 7 and 8.

Follow steps 1-16 to obtain initial thermal image.

	CONTROL	ACTION
1.	Turret travel lock	release
2.	Turret power	on
3.	Night sight power	on
4.	Ballistic sight covers	open
5.	Sensor Select	turn to Clear
6.	Magnification	low
7.	Set sight on object/terrain feature	minimum range 100 meters
[	In limited visibility, reticle	on low]
8.	Magnification	high
9.	Focus Barrel	adjust
10.	Sensor Select	turn to Night
11.	Polarity	white hot
12.	Brightness	set to markings
13.	Contrast	set to markings
14.	Focus	set to markings

15. Look in eye-piece to see if sight has cooled. If it has, then a usable image with color shadings of red through to black will be seen.

16. Adjust focus, if needed, for clearest image.

Thermal sight is now set. Focus must be re-adjusted if magnification is changed, and for objects at different ranges.

DEFINITIONS.

The terms 'scanning', 'detection', 'classification', 'recognition' and 'identification' are used in the procedures that follow. These terms have particular meanings, and the gunner should understand them before he reads any further.

1. SCANNING. Scanning is an ordered and careful method of searching a sector. Its purpose is to find enemy positions and to gain warning of the advance or movement of enemy units.

2. DETECTION. A detection occurs when a gunner notices a source of heat that is new, unusual or different in some way from the rest of the thermal landscape.

3. CLASSIFICATION. Classification is the process of deciding what kind of thing has been detected. It is a two-stage process.

   First, the gunner must try to decide whether it is man-made (a vehicle, a fortified position, a part of a building), or living (an animal, a person), or a natural object such as an area of rock that has been heated by the sun.

   Second, once he has some idea of what it is, he can look for details. For example, if he decides it is a vehicle, he can try to decide whether it is tracked or wheeled, large or small, with or without a gun. From this he can decide whether it is a tank, an APC, a truck or some other vehicle. For a BFV gunner the critical classification to make is between tank and non-tank. This is because only the TOW missile is effective against tanks.

4. RECOGNITION. Recognition is deciding whether the potential target is a friend or foe.

5. IDENTIFICATION. Identification is deciding exactly what the target is. For example, if the target is an enemy tank the gunner may be able to identify which model (T64, T72, T80).

VI. SCANNING PROCEDURE - THERMAL MODE - NIGHT.

Use this procedure to search a sector effectively.

PRE-SCANNING.

When a squad moves into an area, the first task is always to search the area, to ensure that there is no immediate threat. Then the platoon leader will allocate a sector to each squad.

Once a gunner has been given his sector limits, his first task is to make a range card. If the range card is made in daylight, the gunner should check the thermal appearance of all the reference points (RPs) he marks so that he will be able to recognize them at night. If the squad moves into position at night, the gunner should still make a range card. He should do this by identifying key reference points in the landscape using the thermal sight. Because range estimation is difficult at night, the gunner should, where possible, consult the platoon Forward Observer to confirm the BFV's location, and use maps to establish the ranges to the RPs.

Because the gunner may have made his range card some hours before nightfall, when he begins to scan his sector at night (that is with the sight set for thermal operations), he should first:

1. Identify the left limit of sector - confirm azimuth on range card.

2. Identify the right limit of sector - confirm azimuth on range card.

3. Identify the horizon or outer limit of sector - confirm elevation.

4. Locate and identify each reference point marked on the range card and confirm the azimuth and elevation readings.

As each reference point is identified, he should examine it in high magnification and in both black and white hot polarity, so that its thermal appearance is learnt. The thermal appearance of reference points will change when the sun sets, and will probably continue to change as the night progresses. These changes occur as objects begin to lose the heat they have gathered during the day, and because objects are made of different materials, some will lose their heat faster than others.

SCANNING PROCEDURE.

Scanning is a two phase procedure. Phase I provides a systematic coverage of the whole sector. Phase II provides a detailed examination of high risk areas. Phases I and II are alternated.

Phase I. (Sight setting: Low Mag, white hot, reticle off, AP, 1200.)

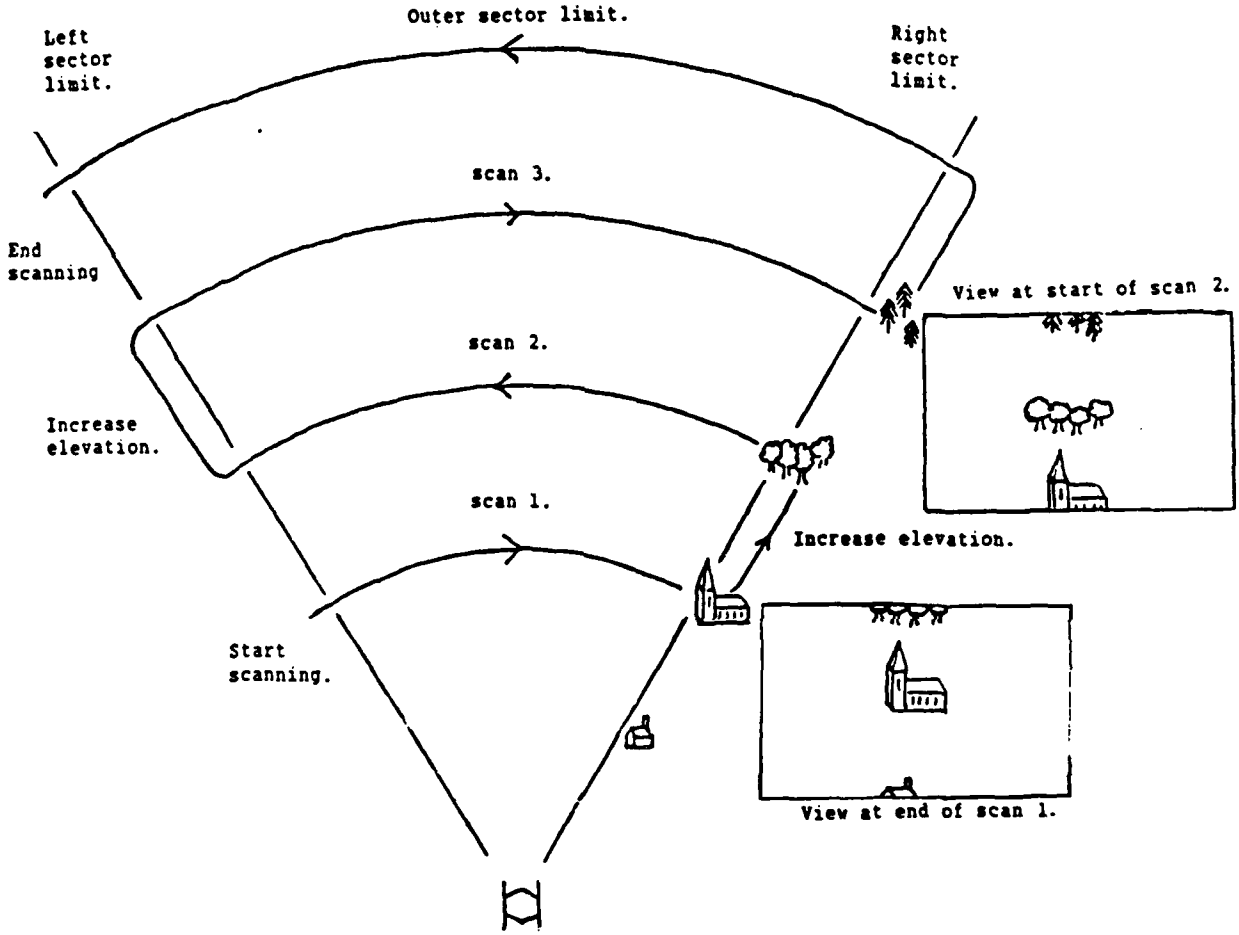
1. Set sight at left or right limit and close in (500-1000 meters).
2. Scan by slowly traversing turret across to the opposite limit.
3. At or near this limit identify a feature (group of trees, open area, building) that is approximately in the middle/upper half of the sight. See diagram 3.
4. Elevate the sight until the identified feature is level with the bottom of the thermal imaging display.
5. Sharpen focus on object or area now in center of sight.
6. Scan by traversing turret back to the opposite limit.
7. Continue alternately elevating the sight and scanning until the horizon or outer sector limit is reached.

Note: Each scan will provide a partial overlap with the previous scan.

Phase II

8. Switch to High Mag.
9. Re-scan the area between approximately 2000 meters and the horizon or outer sector limit. Using the same scanning method as in Phase I above.
10. Check the possible target areas (tree lines, and other covered/concealed approach routes). Use azimuth and elevation readings from range card to locate these, readjust focus for each area.
11. Switch to Low Mag.
12. Return to step 1 and repeat.

Diagram 3. PHASE I SCANNING PATTERN (LOW MAG.)



VII. PROCEDURE FOR DETECTION AND CLASSIFICATION OF TARGETS

A detection occurs when a new or unusual heat source is first noticed, or when a previously unclassified heat source is found to have moved.

WHEN A DETECTION OCCURS:

1. Stop scanning and center the sight on the heat source.

2. Switch to High Mag.

3. Adjust Focus, Brightness and Contrast to obtain clearest image.

IF IMMEDIATE IDENTIFICATION IS NOT POSSIBLE:

4. Switch polarity to black hot to bring out shape and silhouette.

5. Readjust Brightness and Contrast.

6. Alternate between white and black hot, readjusting focus, contrast and brightness as needed. This allows hotter parts, such as the engine area, to be related to the target's shape or silhouette.

WHEN TRYING TO CLASSIFY A DETECTION, ASK TWO QUESTIONS:

a) Is the heat source MOVING? If YES, it is animal, human or a vehicle.

b) Can any REGULAR SHAPES be seen? If YES, it is probably a man-made object. Regular shapes include circles, sharp angles and straight edges.

Regular shapes probably indicate a building, vehicle, tent or position. Movement plus regular shapes is almost certainly a vehicle. If there is no movement and no regular shapes can be seen, it may be a natural object that has been heated by the sun, BUT it may be a concealed enemy position or vehicle.

BEGIN BY ASSUMING THAT IT IS THE ENEMY

If regular shapes can be seen, look for wheels or tracks, and count the number of tires or road wheels. Look at hull shape, and for turret or gun tube. Try to estimate the size of the vehicle, and determine the location of the engine and exhaust. Use this information to try to decide whether the target is a tank, APC, recon vehicle, truck, or a command post or some other military position.

MORE

VII continued.

If you are still unable to classify OR if classification determines the heat source is from a vehicle, personnel or a military position, then

7. Record azimuth and elevation of the heat source.

8. Use reference points from range card to estimate location and range.

9. Report detection and details to platoon leader.

When a platoon leader receives a report of a detection from one of his squads, but where classification was not possible, he should consider directing other vehicles to examine the target. Because the vehicles are spread out, others may be able to see details that the vehicle reporting the detection could not see. The platoon leader may then be able to put the information together, and so determine what the target is.

One last word, the gunner should always take note of the unusual. For example; a small heat source that seems to come and go could be an enemy forward observer exposing himself briefly to scan. In the same way sudden fast movements of wild life may indicate the concealed approach of enemy forces. Recheck such positions at intervals, and report them to the platoon leader.

VIII. RANGE ESTIMATION WHEN USING THE THERMAL SIGHT.

Range estimation is difficult when using the thermal sight. The following guidelines will help.

THE RANGE CARD.

A gunner should already know how to make a range card. Therefore, this section will deal with the range card only in relation to the thermal sight.

At night a well-made range card is the most reliable tool available to the Bradley gunner for estimating range. This is because it can be used on targets that are partly concealed as well as targets that are in the open.

When he is making a range card, the gunner should check the appearance of all target reference points (TRPs) THROUGH THE THERMAL SIGHT, so that he will have some idea of how they will appear at night. For example, on the range card shown in diagram 4 he should examine the 6 TRPs marked. These are:

The windmill (left limit)	The orchard (right limit)
Welch Road bridge	The crossroads
Nelson Road bridge	The junction of Shirley and Nelson roads

Estimates of the ranges to the reference points recorded on the range card should be made by the most accurate means available: LASER Range Finder, binoculars with mil scales, or directly from maps. Often the platoon forward observer (FO) is the best source of information.

When a target is detected through the thermal sight, the gunner will normally estimate its range by referring to the TRPs. For example, if a vehicle was detected leaving the tree line between the crossroads (TRP-4) and the road junction (TRP-6), the gunner can easily spot the place on his range card, and by using the 500-meter circles can estimate the range to the target. In this case he would estimate at about 2700 meters.

This method works well in good weather when the TRPs can be clearly seen through the thermal sight. However, in wet weather, although a vehicle with its engine running will probably be detectable, a TRP like a crossroads may not be visible at all. If this happens it is still possible to estimate the range to the target, but only if the gunner has recorded all the elevations to TRPs on his range card with AP selected and the range control set at 1200 meters.

It works like this: if the gunner has recorded the azimuth and elevation of the TRPs on his range card with AP selected and the range set at 1200; and if he then scans the sector using the same ammo and range settings; he can compare the azimuth and elevation of the target with those of the TRPs. This enables him to determine which TRPs the target is closest to. Once he knows this he can estimate the range.

MORE

For example, imagine that a target is detected. The target azimuth reading is 5600 mils and its elevation is +1 mil. If you look at the data section to the range card (diagram 4) you will see that an azimuth of 5600 mils places it between TRP 3 (5440 mils) and TRP 4 (5830 mils).

TRP 3, the bridge, has an elevation of -5 mils and is at 2000 meters.

TRP 4, the crossroads, has an elevation of +5 mils and is at 2600 meters.

The target had an elevation of 1 mil, about half-way between the elevations of the two TRPs, and therefore its range can be estimated at about half-way between; in this case we might estimate the range at 2300 meters.

If you now look at the range card, you will see that this probably places the target on Welch Road between the bridge and the crossroads.

This method of range estimation is not always this precise, but in poor thermal viewing conditions at night it is probably more accurate than any other method available to the Bradley gunner.

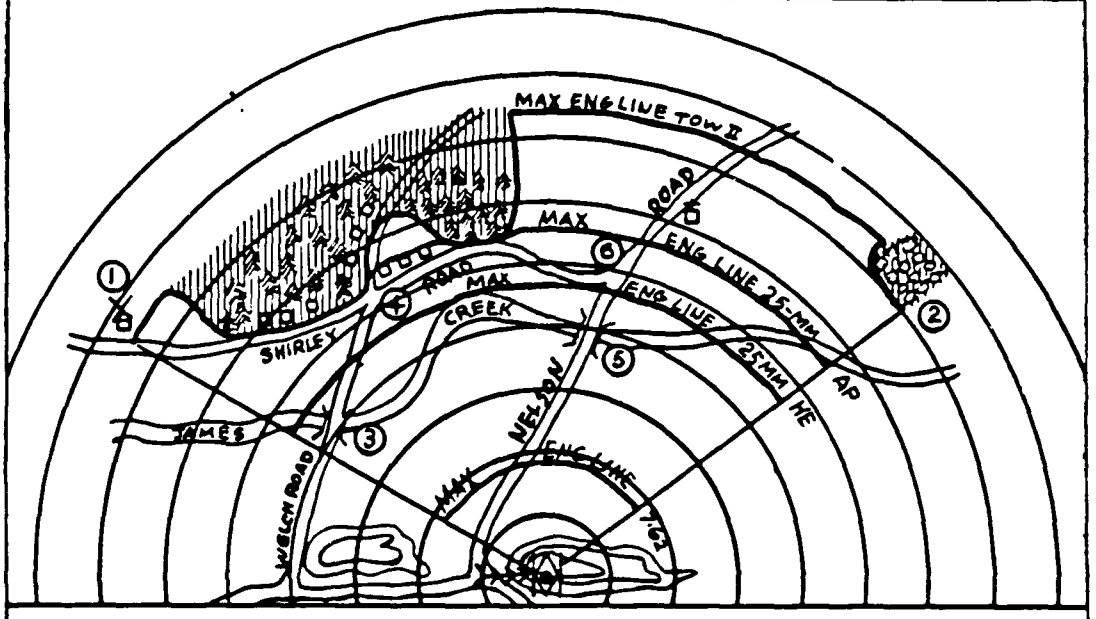
At night, the range card is the best method of estimating distance to target, however the accuracy of the method depends, in part, upon having a sufficient number of TRPs to refer to. The gunner should therefore mark on the range card a number of reference points in addition to the TRPs he is given by the platoon leader. These additional RPs should be at a variety of ranges and across the whole width of the sector. Then, no matter where a detection occurs, the gunner will be able to estimate its range by comparing its position to one or more nearby reference points.

Diagram 4. RANGE CARD

STANDARD RANGE CARD

SQD 1ST
PLT 3RD
CO B

MAGNETIC NORTH



DATA SECTION

POSITION IDENTIFICATION: PRIMARY
DATE: 1 JULY 85 / 0835
WEAPON: BRADLEY B-31
EACH CIRCLE EQUALS METERS: 500

NO	DIRECTION DEFLECTION	ELEVATION 1200/AP	RANGE/AMMO	DESCRIPTION
1	5970‰/5420‰	+7	3900	LEFT LIMIT / WINDMILL
2	1610‰/0920‰	+6	3500	RIGHT LIMIT / ORCHARD
3	5440‰	-5	2000	TRP 1 / BRIDGE WELCH ROAD
4	5830‰	+5	2600	TRP 2 / RJ 501
5	0240‰	-3	2000	TRP 3 / BRIDGE NELSON ROAD
6	0220‰	+2	2400	TRP 4 / RJ 478

REMARKS:
WPNS REF POINT - FROM RJ 460, MAZ 298° 500M

RANGING USING THE RETICLE AND STADIA SIGHTS AT NIGHT.

Targets in the Open

At night, when targets are found in the open and are close enough to be recognized through the thermal sight, then the reticle or the stadia sight can be used in the same way as in the daytime.

It is usually better to set the polarity to black hot before fitting the target into the sight. This is because black hot tends to bring out the shape of the target more clearly.

For targets in the open, this method can work well out to about 2400 meters. This assumes that the weather is reasonably dry. In rain, or in damp weather, the shape of the target will not be clearly defined at such ranges, and therefore this method of ranging will be less accurate.

Targets in Defilade or Concealed Positions

When a target is partly in defilade or camouflaged it may be impossible to use the sights to range directly onto it. If, however, the target is close to an object of known height, then an estimate of range may be made.

Doorways in buildings are generally 2.1 to 2.3 meters high, and a soldier wearing his helmet is a little under 2 meters tall. By chance, soviet tanks are between 2.25 and 2.46 meters high, the BMP is 2 meters high, and other light Soviet armored vehicles range between 1.85 and 2.3 meters high. Therefore, if a tank is close to a building and the doorway of the building can be seen, the gunner can treat the doorway as the height of the tank and range on to that instead. Infantry soldiers standing near a vehicle can be ranged on in the same way.

Summary

Clearly, the enemy will make every effort to conceal his forces, so that opportunities to range onto vehicles in the open will be rare; nor can the gunner rely on the enemy to park near a doorway or similar convenient measuring point. This is why using the range card is recommended as a more reliable method of estimating range at night.

When there is no chance to make a range card, and the enemy vehicle is partly concealed so that the sights cannot be used, the gunner must estimate range as best he can. As a general rule, it is better to under-estimate than over-estimate, because the rounds can be more easily walked onto target.

The exception to this is when firing the TOW. The thermal sight can sense heat from targets beyond the range of the TOW. If the gunner under-estimates the range of target that is beyond maximum range and fires, he will not only lose the missile, but also reveal his presence to the enemy.

Diagram 5. THE RETICLE